SYSTEMS, METHODS, AND ARTICLES OF MANUFACTURE FOR USE IN PANELIZED CONSTRUCTION

Field of the Invention

This invention relates to the field of panelized construction for use in residential, commercial, industrial, and other buildings.

Background of the Invention

On-site building construction, including additions to and renovations of existing buildings, presents numerous inefficiencies and disadvantages. On-site construction is typically slow and labor intensive. Quality control is frequently difficult to maintain during on-site construction. On-site construction may require expertise in numerous construction techniques and building subsystems (e.g., electrical, plumbing, communication systems, heating and cooling, etc.). In most regions, on-site construction may also be limited by variable weather conditions, limited building seasons, and other scheduling difficulties.

In most cases, it is impractical or impossible to build an entire building off-site. Transportation logistics and costs are debilitating. Various techniques for pre-fabricating some or all of a building have been attempted and have been successful to varying degrees. Pre-fabrication provides the labor, material, and time efficiencies of mass production. Pre-fabrication provides the manufacturer with the

ability to monitor quality control under production line conditions. Pre-fabrication may radically decrease the amount of construction time required on-site.

Numerous technical difficulties have been encountered in providing pre-fabricated buildings. Prior techniques may include pre-fabricated building portions that are large and difficult to transport and install. Prior techniques are inflexible and do not allow for individual customization or integration with existing building structures. Prior techniques may not include pre-installation of various building subsystems and do not provide pre-installed subsystems that are fast and easy to complete on site. Prior techniques may be inappropriate for use in commercial and industrial construction.

These and other drawbacks of prior art systems are overcome by the various embodiments of the invention.

<u>Summary of the Invention</u>

The invention may include systems, methods, and articles of manufacture for use in panelized construction of residential, commercial, industrial, and other buildings. Some aspects of the invention may include prefabricated construction panels, methods of using prefabricated construction panels, panelized construction systems with integrated wire-based subsystems, methods of installing panelized construction systems with integrated wire-based subsystems, panelized construction systems with integrated mechanical subsystems, methods of installing panelized

construction systems with integrated mechanical subsystems, panelized construction systems for a commercial or industrial building module, and methods for constructing a commercial or industrial building module.

One aspect of the invention may be a construction panel for use in building construction, including building additions and renovations. The construction panel may include a plurality of peripheral frame members that define a rectangular frame. A plurality of stud members within the rectangular frame may extend from a first portion of the frame to an opposite second portion of the frame and may be parallel to at least one edge of the frame. These stud members may define spaces within the rectangular frame between adjacent stud members and between stud members and adjacent peripheral members of the frame. In some embodiments, the spaces may accommodate insulation, portions of one or more building subsystems, or other internal structures. The frame may also define a first and second rectangular surface along first and second opposite faces of the peripheral frame members and stud members. First and second surface covering layers, such as dry wall or exterior sheathing, may be disposed on the first and second rectangular surfaces. The frame may accommodate fasteners for connecting the frame to an adjacent structure, such as another construction panel or a pre-existing portion of a building.

Another aspect of the invention may be a method of using prefabricated construction panels. The method may include preparing a pre-existing building to

accommodate one or more prefabricated construction panels. At least one construction panel may be placed adjacent to a building structure defining a portion of the pre-existing building. The construction panel may be attached to the adjacent building structure. Attachment of the construction panel to the adjacent building structure may define one or more seams between a surface covering layer of the construction panel and one or more surface covering layers of the building structure. At least one seam between the construction panel and the building structure may be covered to integrate the prefabricated construction panel into the pre-existing building.

Still another aspect of the invention may be a panelized construction system with integrated wire-based subsystems, such as electrical, communication, and security systems. The panelized construction system may include a construction panel with a built-in surface device, such as an outlet, switch, fixture, or other device, for a wire-based subsystem. The surface device may be electrically connected by wires internal to the construction panel to a junction box that can be accessed from outside the panel. The construction panel may define a guide conduit extending from an edge of the construction panel to the junction box, allowing a connecting wire to be inserted into the guide conduit and electrically connected to the surface device through the junction box.

An additional aspect of the invention may be a method of installing a panelized construction system with integrated wire-based systems. A construction

panel including a surface device for a wire-based subsystem may be positioned for installation. The construction panel may be fixed in place, such as by attaching it to an adjacent construction panel or building structure. A connecting wire may be run to the construction panel and electrically connected to the surface device through a junction box in the construction panel. The connecting wire may be electrically connected to a source for the wire-based subsystem.

A further aspect of the invention may be a panelized construction system with an integrated mechanical subsystem. The system may include one or more construction panels. At least one construction panel may have a conduit for the mechanical subsystem built into the construction panel and extending to an edge of the construction panel. The conduit may be functionally connected to a surface device, such as a vent, for the mechanical subsystem, also built into the first construction panel. The conduit may also be functionally connected at the edge of the construction panel to a source for the mechanical subsystem.

A still further aspect of the invention may by a method of installing a panelized construction system with an integrated mechanical subsystem. The method may include the positioning of a construction panel with a built in surface device for a mechanical subsystem and a built in first conduit extending from the surface device to an edge of the construction panel. The construction panel may be fixed in place. A second conduit, functionally connected to a source for the mechanical subsystem, may be engaged to the first conduit such that the first

conduit if functionally connected to the second conduit and the source. In some embodiments, additional construction panels with conduits may be positioned, the conduits may be engaged to the conduit of an adjacent construction panel, and the construction panels may be fixed in place.

Yet another aspect of the invention may be a panelized construction system for commercial or industrial buildings. The panelized construction system may include a plurality of prefabricated wall panels and prefabricated roof panels. The prefabricated wall panels and prefabricated roof panels may be attached to adjacent panels using a plurality of fasteners. Placement and attachment of the prefabricated wall panels and prefabricated roof panels may be defined by a building module configuration.

Still another aspect of the invention may be a method of constructing a commercial or industrial building module. The method may include preparing a base structure according to a building module configuration. A plurality of wall panels may be positioned above the base structure. The plurality of wall panels may be attached to the base structure and each adjacent wall panel. A plurality of roof panels may be positioned above the plurality of wall panels. The plurality of roof panels may be attached to at least some of the wall panels and to each adjacent roof panel.

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate an embodiment of the invention and, together with the description, serve to explain the principles of the invention.

Brief Description of the Drawings

Figure 1 is a front view of an example vertical panel for use in panelized construction.

Figure 2 is a front view of a second example vertical panel.

Figure 3 is a front view of a third example vertical panel.

Figure 4 is a front view of a fourth example vertical panel.

Figure 5 is a front view of a frame for an example vertical panel, such as the example vertical panel of Figure 1.

Figure 6 is a side view of an example vertical panel, such as the example vertical panel of Figure 1.

Figure 7 is a side cross-sectional view of an alternate configuration for an example vertical panel, such as the example vertical panel of Figure 1.

Figure 8 is a top view of an example pitched panel for use in panelized construction.

Figure 9 is a top view of a second example pitched panel.

Figure 10 is a side cross-sectional view of an example pitched panel, such as the example pitched panel of Figure 8.

Figure 11 is a cross-sectional view of a frame for an example pitched panel, such as the example pitched panel of Figure 8.

Figure 12 is a top view of an example horizontal panel for use in panelized construction.

Figure 13 is a bottom view of an example horizontal panel, such as the horizontal panel of Figure 12.

Figure 14 is a side cross-sectional view of an example horizontal panel, such as the horizontal panel of Figure 12.

Figure 15 is a side cross-sectional view of an alternate example horizontal panel, such as the horizontal panel of Figure 12.

Figure 16 is a top view of a frame of an example horizontal panel, such as the horizontal panel of Figure 12.

Figure 17 is a schematic top cross-sectional view of an example building for renovation.

Figure 18 is a schematic top cross-sectional view of the example building for renovation of Figure 17 after removal of various pre-existing building structures.

Figure 19 is a schematic top cross-sectional view of the example building for renovation of Figure 17 after placement of sills.

Figure 20 is a schematic top cross-sectional view of the example building for renovation of Figure 17 after placement of a plurality of vertical panels.

Figure 21 is front view of an example attachment mechanism for attaching construction panels to adjacent structures, including other construction panels.

Figure 22 is a top view of an example attachment mechanism for attaching construction panels to adjacent structures, including adjacent construction panels.

Figure 23 is a side cross-sectional view of an example attachment mechanism for attaching vertical panels to a base structure.

Figure 24 is a front view of an example attachment mechanism attaching adjacent vertical panels to each other and a base structure.

Figure 25 is a front view of a plurality of vertical frames and a wire-based subsystem of an example panelized construction system.

Figure 26 is a side view of a base portion of an example panelized construction system with a wire-based subsystem.

Figure 27 is a flow chart of an example method of installing a panelized construction system with a wire-based subsystem.

Figure 28 is a top view of a portion of horizontal panel frames and a mechanical subsystem of an example panelized construction system.

Figure 29 is a front view of a vertical panel frame and mechanical subsystem of an example panelized construction system.

Figure 30 is an example connection between the conduits of adjacent construction panels for an example panelized construction system with a mechanical subsystem.

Figure 31 is a an example connection between the conduits of adjacent construction panels for an example panelized construction system with a mechanical subsystem.

Figure 32 is a an example method for installing a panelized construction system with a mechanical subsystem.

Figure 33 is a front view of a frame for an example vertical panel for use in panelized construction of commercial or industrial buildings.

Figure 34 is a front view of a frame for a second example vertical panel for use in panelized construction of commercial or industrial buildings.

Figure 35 is a side cross-sectional view of a third example vertical panel for use in panelized construction of commercial or industrial buildings.

Figure 36 is a cross-sectional view of an example commercial or industrial building using panelized construction.

Figure 37 is an example attachment mechanism for attaching adjacent panels.

Figure 38 is an example attachment mechanism between a vertical panel with a bearing ledger and a horizontal panel.

Figure 39 is an alternate example attachment mechanism between a vertical panel with a bearing ledger and a horizontal panel.

Figure 40 is an example attachment mechanism between vertical panels defining a pocket and a horizontal panel.

Figure 41 is an example attachment mechanism between a vertical panel and a base structure.

Figure 42 is a top view of an example building configuration for use in panelized construction of commercial and industrial buildings.

Figure 43 is a top view of a second example building configuration for use in panelized construction of commercial and industrial buildings.

Figure 44 is a flow chart of an example method of constructing a commercial or industrial building using panelized construction.

Detailed Description of the Preferred Embodiments

With reference to the drawing figures generally, and particularly to Figures 1-16, a variety of example construction panels for use in panelized construction are shown. Figures 1-7 show a variety of horizontal panel configurations, such as those used for walls. Figures 8-11 show a variety of pitched panel configurations, such as those used for pitched roofs and ceilings. Figures 12-16 show a variety of horizontal panels, such as those used for floors, ceilings, and flat roofs. Figures 17-20 show an example use of construction panels to renovate a building. Figures 21-24 show a variety of example attachment mechanisms for attaching construction panels to adjacent structures. Figures 25-27 relate to an example of a wire-based subsystem for use in panelized construction systems. Figures 28-32 relate to an example of a mechanical subsystem for use in panelized construction systems.

Figures 33-44 relate to panelized construction of commercial or industrial buildings.

Construction Panels

Figures 1-16 show a variety of example construction panels. These construction panels may generally be grouped by function. Figures 1-7 show vertical panels. Vertical panels are generally rectangular and intended to be installed in an upright position to define at least a portion of a building wall or other vertical structure. Wall panels are generally vertical panels. Figures 8-11 show pitched panels. The pitched panels shown are for defining at least a portion of a pitched roof and are installed at an angle between support structures at either end of the panel, such as a wall and a ridge beam, support ledger, post, or other support. In some building, such as those with cathedral ceilings, finished attics, etc., pitched panels may also act as pitched ceiling panels. Some roof panels, ceiling panels, and combined roof/ceiling panels are pitched panels. Figures 12-16 show horizontal panels. The horizontal panels shown are designed to be installed in a horizontal position to define at least a portion of a floor, ceiling, flat roof, or some combination thereof. Some roof, ceiling, and combined roof/ceiling panels are horizontal panels. Most floor, ceiling, and combined floor/ceiling panels are horizontal panels.

The horizontal panels of Figures 1-7 are wall panels and may be designed with various dimensions, materials, purposes, features, and subsystems. For

example, Figure 1 shows a wall panel 100 with several surface devices. As shown, panel 100 includes a vent 110 for a mechanical subsystem, as well as a switch 120 and outlet 130 for one or more wire-based subsystems. Figure 2 shows a wall panel 200 with a door 210. Figure 3 shows a wall panel 300 with a window 310 and an outlet 320. Figure 4 shows a wall panel 400 with a built in support truss 410 and an outlet 420.

The dimensions of any given wall panel may vary depending on the purpose of the wall panel. A number of wall panels may be positioned next to one another such that the widths of the adjacent wall panels define the length of a full wall or portion of a wall. Because wall lengths vary depending on, among other things, the size of the room the walls are defining, widths of the individual wall panels may be variable. In one embodiment, most wall panels are fabricated to a standard width and a smaller number of wall panels of variant widths are used to adjust for length increments that are not divisible by the standard panel width. In a preferred embodiment for use in domestic residential construction, standard wall panels are fabricated in 4' widths and non-standard wall panels are fabricated in smaller widths. Four foot widths assist in ease of productions as many sheet building materials, such as drywall and exterior sheathing, are sold in 4' widths. Four foot wall panels are also small and light enough to be maneuvered with minimal equipment and manpower, making such wall panels accessible to contractors and do-it-yourselfers. Heights of the wall panels may also vary. In a preferred

embodiment for domestic residential construction, wall panels may be fabricated with 8' heights. Eight foot high wall panels also assist in ease of production, since many sheet building materials are sold in 8' lengths. However, wall panels may also be fabricated for half walls (3-4' high), 9-10' luxury ceilings, basements with lower ceilings, or other dimensions as appropriate to the building. Commercial, industrial, and other non-residential building may have variant wall heights much larger than those for residential buildings. Wall panel thickness may also vary. Thickness may be dependant on the structural requirements of the wall panel, the number and type of surface covering layers, and the thickness of the frame members.

The materials used for fabrication of a wall panel may vary according to the structural requirements, available materials, preferences, and applicable building regulations for any given purpose. Any given project may include a variety of wall panels with varying materials and material configurations based upon the purpose of the particular wall panel. Each wall panel may generally include a frame and one or more surface covering layers. For example, Figure 5 shows an example wall panel frame 500. Frame 500 includes a rectangular outer frame 510. Outer frame 510 is comprised of two members defining each side of the rectangle and an edge of the wall panel. Top members 511 and 512 define the top side of the outer frame 510 and the top side of top member 511 may define the top edge of the wall panel. Bottom members 513 and 514 define the bottom side of the outer frame 510 and the

bottom side of bottom member 514 may define the bottom edge of the wall panel. Lateral frame members 515 and 516 define a first lateral side of the outer frame 510 and the outer side of lateral frame member 515 may define a first lateral edge of the wall panel. Lateral frame members 517 and 518 define a second lateral side of the outer frame 510 and the outer side of lateral frame member 518 may define a second lateral edge of the wall panel. The frame 500 may also include a number of stud members 520 and 521 extending from top member 512 to bottom member 513, parallel to lateral frame members 515, 516, 517, and 518. Lateral frame members 515, 516, 517, and 518 may also be considered stud members. The stud members define spaces 530, 531, and 532 between lateral frame members 561 and 517, and adjacent stud members 520 and 521. The spaces may accommodate internal layers, such as insulation, or portions of various building subsystems. In a preferred embodiment for use in domestic residential construction, the various members of the frame are comprised of 2x4 building grade lumber and the stud members are placed no greater than 16" apart. For other types of construction, different materials and configurations may be employed for the frame, such as larger lumber members (e.g., 2x6, 2x10, etc.), light gage structural metal members, pre-cast concrete, extruded or cast structural polymers and composites, recycled materials, and other materials. Stud distances may vary in accordance with the structural requirements of the frame materials and relevant building codes. Other material variations include the surface covering materials disposed on one or more surfaces

defined by the frame. For example, frame 500 defines two surfaces parallel to the front and back edges of the frame members which may accommodate surface covering layers. Figures 6 and 7 show side views of two example configurations of surface covering layers for wall panels. Wall panel 600 includes a frame 610, a first surface covering layer 620 disposed on a first surface of frame 610, and a second surface covering layer 621 disposed on an opposite second surface of frame 610. Wall panel 700 includes a frame 710, a second surface covering layer 720 disposed on a first surface of frame 610, a second surface covering layer 721 disposed on an opposite second surface of frame 610, and a third surface covering layer 722 disposed on the second surface covering layer 721. Surface covering layers may include a variety of materials for covering a building surface, such as sheathing, drywall, paneling, siding, or other building materials. A surface covering layer need not cover the entire surface of a wall panel. Surface covering layers may be attached to the frame during fabrication by any method appropriate, such as fasteners, adhesives, mated connections, or other attachment methods.

Frame size, spacing, and material and surface covering layer number and materials may be determined by the purpose of a particular wall panel. Different building types, such as residential, commercial, and industrial building, may have different design considerations. Similarly, within a particular type, there may be variations in building style depending on climate, expected use, costs, and other factors. Even within a specific building, wall panel's purpose may vary such that

there may be substantial variations in the wall panels. For example, building may have different configurations for internal and external walls. Internal walls may have surface covering layers, such as dry wall, on both sides, while external walls may have a double surface covering layers on the exterior including sheathing and siding. A wall panel that backs up to a foundation wall or is otherwise accessible from only one side may not have surface covering layers on both sides. The number and type of surface covering layers may vary widely. Additionally, the structural considerations of a building may determine variations in the walls. For example, some walls may be load bearing, while others are non-load bearing. Some building designs may include some wall panels that have more stringent structural requirements to act as shear walls. Wall panels may be provided with core layers, such as insulation, of varying type and rating. For example, core layer 730, shown in Figure 7, may include R19 insulation.

Built in features of wall panels may vary greatly. Doors and windows of varying sizes and configurations may be built into wall panels. The frames of these wall panels may have different configurations of studs and horizontal members to accommodate and support such features. In some embodiments, a single feature may be embodied in multiple wall panels or a larger than standard wall panels may be provided to accommodate larger features. For example, a 6' sliding glass door may be provided in a single 8' wide wall panel. Other built in features may include shelves, cabinets, fixtures, fireplaces, and other structures.

Built in subsystems in wall panels may also vary greatly. Subsystems may include electrical, communication, security, mechanical, plumbing, gas, and other building subsystems. Portions of one or more subsystems may be installed in a wall panel. In some cases, portions in one panel may be connected directly to portions in an adjacent panel. In some cases, additional components may be used to connect portions of the system in different wall panels. Portions of multiple subsystems may be installed in a single wall panel. Preinstalled portions of subsystems may include surface devices, such as vents, thermostats, outlets, switches, electrical boxes, hubs, sensors, fixtures, appliances, and other subsystem components. Preinstalled portions of subsystems may include connective components as well, such as wires, conduits, junctions, wireless connections, and other connective components. Further description of example electrical and mechanical systems are described below with reference to Figures 25-27 with reference to wire-based subsystems and 28-35 with reference to mechanical subsystems.

The pitched panels of Figures 8-11 are roof panels, which may have ceiling surface covering layers and also be referred to as roof/ceiling panels. Roof panels may vary in dimensions, materials, purpose, features, and subsystems in a manner similar to wall panels. The comments provided above with regard to wall panels apply to roof panels as well. Figure 8 shows an example roof panel 800. Figure 9 shows an example roof panel 900 with a built in skylight 910. Figure 10 shows a

side cross-sectional view of a roof panel 1000 showing surface covering layers 1020, 1021, and 1022 and core layer 1030. Figure 11 shows the frame 1110 of a roof panel 1100.

Dimensions of roof panels may be determined by the dimensions of the building the roof panels are for and take into consideration ease of manufacture and handling, much as with wall panels. In a preferred embodiment, roof panels may be a standard width of 4'. The length of the roof panels may be determined by width of the building and the pitch of the roof. Thickness of the roof panels may be determined by the material selections for the frame and surface covering layers.

A variety of materials may be used for fabricating roof panels. As shown in Figure 10, a roof panel 1000 includes a frame 1010, a first surface covering layer 1030, a second surface covering layer 1031, a third surface covering layer 1032, and a core layer 1040. Frame 1010, surface covering layers 1020, 1021, and 1022, and core layer 1030 may each be made from a variety of materials. In a preferred embodiment, Frame 1010 includes wooden members of varying dimensions, such as 2x4, 2x6, 2x8, 2x10, 2x12, etc. depending on the position and purpose of the member. The position of various members in the frame are shown in Figure 11. Frame 1110 includes upper end members 1111, 1112 1113, and 1114, side members 1122, 1123, 1125, and 1126 and lower end member 1121, which define a rectangular frame and an upper surface. Frame 1110 may also include a stud member 1124, cross members 1115, 1116, 1117 and 1118, and lower support

engaging members 1119 and 1120. Upper end members 1111 and 1112, side members 1122, 1123, 1125, and 1126, and cross members 1115, 1116, 1117, and 1118 may define a lower surface. Upper end members 1111, 1112, 1113, and 1114 side members 1122, 1123, 1125, and 1126, and stud member 1124 may use a large member to provide the structural integrity of the roof panel. Lower end member 1121 and lower support engaging members 1019 and 1020 may use mid-sized members to compensate for the angle of the lower end, engage a lower support structure, such as a wall panel, and provide structural integrity to the roof panel. Cross members 1120 and 1121 may use the smallest members to assist in defining the lower surface, supporting any surface covering layer applied to the lower surface, and providing structural integrity to the roof panel. Like wall panels, roof panels may employ a variety of surface covering layers. For example, roof panel 1000 includes surface covering layers 1020, 1021, and 1022. In a preferred embodiment, surface covering layer 1020 may be an external roofing material, such as shingles. Surface covering layer 1021 may be an under layer, such as sheathing material. Surface covering layer 1022 may be an interior covering layer, such as drywall. Some roof panels may not employ a lower surface covering layer where the area immediately under the roof is unfinished, such as in an attic or other design with separate ceiling panels. In some buildings, particularly non-residential buildings, exterior sheathing may include sheet metal, corrugated polymers, or similar sheet roofing materials. A single exterior surface covering layer may be

used. As with wall panels, the number of interior and exterior layers may vary widely and include any number of intermediate layers between exterior surface layers and any under layer.

The variety of purposes for roof panels is similar to that for wall panels in that it can vary greatly according to building type and style, as well as the particular configuration of any roof portion on any given building. Material and size variation, load requirements, support structure, features and subsystems, and other factors may determine frame structure and other details of a roof panel. A single building may have multiple roof portions with varying spans, pitches, support structures, and internal and external surface covering materials. For example, a single residence may include a large, steeply pitched main peak, a smaller lower pitched garage peak, a pitched porch roof, and several dormers. The structural requirements of a dormer or a porch roof may be much different than the requirements of the main roof.

The features incorporated into roof panels may also vary. Skylights of different sizes and configurations may be incorporated into roof panels. For example, roof panel 900 incorporates skylight 910. Some roof panels may include translucent or transparent surface covering materials such that the panel is functionally a skylight. Trap doors, chimneys, and other features may also be included in a roof panel design.

A variety of subsystems may also be incorporated into roof panels. Portions of any subsystem may be included in a roof panel. For example, vents for mechanical and plumbing systems, solar panels, mounting systems for roof mounted HVAC units and other appliances, and other external surface devices may be incorporated in a roof panel. Similarly, roof panels may include vents, fixtures, appliances, and other internal surface devices. Wires, conduits, and other connective portions of subsystem may also be incorporated in the roof panels. Multiple subsystems may be incorporated into a single roof panel and portions of a subsystem may be distributed across multiple panels. Further description of example wire-based and mechanical subsystems are described below.

Like vertical panels and pitched panels, there may be a wide variety in dimensions, materials, purposes, features, and subsystems installed in horizontal panels. Figure 12 shows the top of a horizontal panel 1200. Figure 13 shows the bottom of a ceiling panel 1300, including surface devices 1310 and 1311. Figure 14 is a side cross-sectional of a horizontal panel 1400 with surface covering layers 1420, 1421, and 1422. Figure 15 is a side cross-sectional view of a horizontal panel 1500 with surface covering layers 1520, 1521, 1522, and 1523. Figure 16 is a top view of a frame 1600 for a horizontal panel.

Dimensions of horizontal panels may be determined by the dimensions of the building the panels are for and take into consideration ease of manufacture and handling, much as with wall and roof panels. In a preferred embodiment, floor,

ceiling, and roof panels may be a standard width of 4'. The length of the horizontal panels may be determined by the span between support structures for the particular panel. Thickness of the horizontal panels may be determined by the material selections for the frame and surface covering layers.

A variety of materials may be used for fabricating horizontal panels. As shown in Figure 14, a horizontal panel 1400 includes a frame 1410, a first surface covering layer 1420, a second surface covering layer 1421, a third surface covering layer 1422, and a core layers 1430 and 1431. Figure 15 shows an alternate example where horizontal panel 1500 includes a frame 1510, a first surface covering layer 1520, a second surface covering layer 1521, a third surface covering layer 1522, a fourth surface covering layer 1523, and a core layers 1530 and 1531. Frames 1410 and 1510, surface covering layers 1420, 1421, 1422, 1520, 1521, 1522, and 1523 and core layers 1430, 1431, 1530, and 1531 may each be made from a variety of materials. In a preferred embodiment, frames 1410 and 1510 include wooden members of varying dimensions, such as 2x4, 2x6, 2x8, 2x10, 2x12, etc. depending on the position and purpose of the member. The wooden members may by composite floor joists. The position of various members in an example frame 1600 are shown in Figure 16. Frame 1600 includes lateral side members 1610, 1611, 1612, and 1613 and end members 1614 and 1615 defining a rectangular frame. Joist members 1616 and 1617 extend from end member 1614 to end member 1615 parallel to side members 1610, 1611, 1612, and 1613. Cross members 1620, 1621,

1622, 1623, 1624, 1625, 1626, 1627, and 1628 extend between adjacent joist members 1616 and 1617 and adjacent side members 1611 and 1612. Like wall panels and roof panels, horizontal panels may employ a variety of surface covering layers. In a preferred embodiment, surface covering layers 1420, 1421, 1422, 1520, 1521, 1522, and 1523 may be any combination of sheathing or under flooring, drywall, ceiling paneling, external roofing material, padding, flooring, or other materials. For example, a combination roof/ceiling panel may include sheathing and tar sealant on the top side and drywall on the bottom side. A floor/ceiling panel may include under flooring and flooring material on the top side and ceiling panels on the bottom side. Some horizontal panels may not employ a lower surface covering layer or an upper surface covering layer where the area immediately under the roof or floor is unfinished or the area above the ceiling is unfinished. As with other construction panels, the number of interior and exterior layers may vary widely and include any number of intermediate layers between exterior surface layers and any under layer.

The variety of purposes for horizontal panels is large and can vary greatly according to building type and style, as well as the particular configuration of any roof portion on any given building. Material and size variation, load requirements, support structure, features and subsystems, and other factors may determine frame structure and other details of a horizontal panel. A single building may have multiple purposes for horizontal panels, including roofs, floors, and ceilings.

Spans, support structures, load requirements, and internal and external surface covering materials may differ even on a single level, as well as across multiple horizontal levels of a building.

The features incorporated into horizontal panels may also vary. Horizontal panels may incorporate features of both wall panels and roof panels as described above.

A variety of subsystems may also be incorporated into horizontal panels. Portions of any subsystem may be included in a horizontal panel. Horizontal panels may incorporate features of both wall panels and roof panels as described above. For example, horizontal panel 1300 incorporates surface devices 1310 and 1311.

In a preferred embodiment, construction panels are prefabricated according to standards meeting the building codes of one or more jurisdictions. The construction panels may also be designed and manufactured to conform with other verified safety standards, such as those administered by Underwriters Laboratories, Inc. For example, residential building panels may be designed to conform to minimum material standards, stud spacing, height of windows, location of electrical outlets and switches, and other requirements. Construction panels may be insulated to meet minimum requirements. Combinations of surface layer materials, frame materials, and core materials may also be used for construction panels meeting specific fire rating requirements or other special purpose requirements.

Construction panels may be used for a variety of purposes. For example, a number of construction panels, including wall, roof, and possibly floor and ceiling panels, may be used to build a new building according to a building module configuration. Similarly, construction panels may be used to build an addition to an existing building or a portion of a building site built or built using other techniques. Construction panels may also be used independently or in small groups to accent other construction techniques, make minor additions to an existing building, or assist in renovation of an existing building. Figures 17-20 show four stages of construction on building 1700 using construction panels. In the example shown, only vertical panels are employed, but pitched, horizontal, or other panels could be used in substantially the same way.

Figure 17 shows a pre-existing building 1700. Building 1700 includes a floor 1710 and exterior walls 1720, 1721, 1722, and 1723. Building 1700 also includes an exterior door 1724 in exterior wall 1721, an internal wall 1725 with a door 1726, and a stairway 1728. For example, building 1700 could be the unfinished basement of an existing residence divided into two utility rooms by an unfinished stick-built wall (internal wall 1725). having a sliding glass door (exterior door 1724) to the back yard, and a concrete floor (floor 1710). The owner might desire to renovate the basement and finish it for use as a family room.

In Figure 18, building 1700 has been prepared for renovation by stripping pre-existing structures incompatible with the owner's desired building

configuration. Preparation may include demolishing and removing pre-existing walls, floors, ceilings, and doors and other features. Preparation may include stripping pre-existing structures to underlying structures, such as removing finishing and drywall to expose wall frames, or ripping out old flooring to expose the sub-floor. Preparation may include minor site-built construction or modification of existing structures in order to define one or more spaces compatible with a particular construction panel size or configuration. In the present example, exterior wall 1721, including exterior door 1724, has been removed. A portion of internal wall 1725, including internal door 1726, has been removed and internal wall portion 1827 remains.

In Figure 19, sills 1930, 1931, 1932, 1933, 1934, and 1935 have been attached to floor 1710. Sills 1930, 1931, 1932, 1933, 1934, and 1935 may provide a portion of an attachment mechanism for one or more construction panels and may assist in positioning those construction panels. Sills 1930 and 1931 have been placed between internal wall portion 1827 and a wall of stairway 1728 in order to define a location for positioning a wall panel with a door. Sill 1932 has been placed parallel to exterior wall 1720 in order to define a location for positioning one or more interior wall panels. Sills 1933 and 1934 have been placed parallel to the opening created by the removal of exterior wall 1721. Sills 1933 and 1934 define a location for positioning one or more exterior wall panels, include a wall panel with a door. Sill 1935 has been placed parallel to exterior wall 1722 in order

to define a location for one or more interior wall panels. Sills 1930, 1931, 1932, 1933, 1934, and 1935 may be attached to floor 1710 using a variety of attachment mechanisms, depending on the materials of floor 1710 and sills 1930, 1931, 1932, 1933, 1934, and 1935. For example, floor 1710 may be a concrete floor and sills 1930, 1931, 1932, 1933, 1934, and 1935 may be attached using anchors drilled into the concrete. Alternatively, floor 1710 may be wood and fasteners such as bolts, screws, or nails could be used to attach sills 1930, 1931, 1932, 1933, 1934, and 1935.

In Figure 20, a plurality of wall panels 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, and 2049 are positioned over sills 1930, 1931, 1932, 1933, 1934, and 1935. Wall panels 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, and 2050 may be attached to each other, sills 1930, 1931, 1932, 1933, 1934, and 1935, and/or pre-existing building structures, such as floor 1710, exterior walls 1720 and 1722, stairway 1728, and interior wall portion 1827. Wall panel 2040 is a vertical panel with a pre-installed door. Wall panel 2040 is positioned over and attached to sills 1930 and 1931. Wall panel 2040 may be attached to the wall of stairway 1728, interior wall portion 1827, and/or floor 1710 or a portion of the ceiling (not shown). Wall panel 2040 may separate a newly formed closet 2060 from a family room 2061. Wall panels 2042, 2042, and 2043 may be interior vertical construction panels for providing a finished wall in family room 2061. Wall panels 2041, 2042, and 2043 are positioned over and attached to sill 1932.

Wall panel 2041 may be attached to interior wall portion 1827 and wall panel 2042. Wall panel 2042 may be attached to wall panels 2041 and 2043. Wall panel 2043 may be attached to wall panels 2042 and 2044. Wall panels 2041, 2042, and 2043 may each be attached to floor 1710, a portion of the ceiling (not shown), and/or exterior wall 1720. Wall panels 2044, 2045, and 2046 may be exterior vertical construction panels for providing a finished and exterior wall for family room 2061. Wall panel 2045 may include a pre-installed door, such as a set of French doors, for providing access from family room 2061 to a backyard (not shown). Wall panels 2044, 2045, and 2046 are positioned over and attached to sills 1933 and 1934. Wall panel 2044 may be attached to exterior wall 1720, wall panel 2043, and wall panel 2045. Wall panel 2045 may be attached to wall panels 2044 and 2046. Wall panel 2046 may be attached to wall panels 2045 and 2047 and exterior wall 1722. Wall panels 2044, 2045, and 2046 may be attached to floor 1710 or a portion of the ceiling (not shown). Wall panels 2047, 2048, 2049, and 2050 may be interior vertical construction panels for providing a finished wall for family room 2061. Wall panels 2047, 2048, 2049, and 2050 may be positioned over and attached to sill 1935. Wall panel 2047 may be attached to wall panels 2046 and 2048. Wall panel 2048 may be attached to wall panels 2047 and 2049. Wall panel 2049 may be attached to wall panels 2048 and 2050. Wall panel 2050 may be attached to wall panel 2049 and a wall portion of stairway 1728. Wall panels 2047, 2048, 2049 ,and 2050 may be attached to floor 1710, a portion of the ceiling (not shown), and/or

exterior wall 1722. After the construction panels are positioned and attached, the seams created between each construction panel and adjacent structures (both pre-existing building structures and other construction panels) may be covered. Covering seams may include placing seam covering materials, such as adhesive tape, putty, joint compound, cover plates, or other materials, over the seams. After seams are covered, additional finishing may be done, such as painting, wall papering, adding molding, or other finishing.

Construction panels may be attached to one another and adjacent structures using a variety of attachment mechanisms. Nuts and bolts, screws, nails, latches, clips, and other mechanical fasteners are all possible. Adhesives, welds, mating surfaces, and other attachment mechanisms may also be possible. In a preferred embodiment, mechanical fasteners are used to attach construction panels to adjacent structures. Attachment mechanisms for attaching construction panels to adjacent structures are shown in Figures 21-24. Figures 21 and 22 show a fastener and strap attachment mechanism for attaching adjacent building structures. Figures 23 and 25 show a combination of attachment mechanisms used for attaching adjacent vertical construction panels to one another and to a floor using a sill, as described above with regard to Figures 17-20.

Figure 21 shows a side view of a fastener and strap attachment mechanism for attaching adjacent structures, such as a construction panel to another construction panel or a construction panel to an adjacent building structure. Figure

21 shows a first building structure 2110 and a second building structure 2111 positioned adjacent each other and defining a seam 2112. Seam 2112 is shown as a gap between first building structure 2110 and second building structure 2111. However, in a preferred embodiment, the adjacent building structures are placed snuggly in contact with one another and seam 2112 does not include a gap. A strap 2120 is located in contact with first building structure 2110 and second building structure 2111, spanning seam 2112. A number of fasteners 2130, 2131, 2132, and 2133 extend through strap 2120 and into first building structure 2110 and second building structure 2111. Strap 2120 may be made of metal, plastic, or another material. Strap 2120 may define a plurality of holes for accommodating a shaft portion of the fasteners, but not allowing a head portion to pass though. Straps may be configured in alternate shapes, such as L's, T's, and other shapes for conforming to the attachment surfaces and orientations of adjacent structures.

Figure 22 shows a top view of a plurality of fastener and strap attachment mechanisms used to attach adjacent building structures. A first construction panel 2210 and a second construction panel 2220 are positioned adjacent one another defining a seam 2230. First construction panel 2210 includes a frame 2211 and Second construction panel 2220 includes a frame 2221. A first strap 2240 and a second strap 2250 are positioned in contact with frame 2211 and frame 2221 spanning seam 2230. Fasteners 2241 and 2242 attach first strap 2240 to frame 2211 and fasteners 2243 and 2244 attach first strap 2240 to frame 2221. Fasteners

2251 and 2252 attach second strap 2250 to frame 2211 and fasteners 2253 and 2254 attach second strap 2250 to frame 2221.

Figure 23 shows an attachment mechanism for attaching a vertical construction panel 2310 to a base structure 2320, such as a floor, by mating the bottom of construction panel 2310 with a complementary sill 2330. Construction panel 2310 includes a frame 2311. Frame 2311 includes a base member 2312 extending approximately the width of frame 2311. Frame 2311 also includes a sill compliment member 2313 extending only a portion of the width of frame 2311. Base member 2312 and frame compliment member 2313 are integral to frame 2311. A bottom side of sill compliment member 2313 engages base structure 2320. Sill member 2330 engages base member 2312 and sill compliment member 2313. The combined width of sill member 2330 and sill compliment member 2313 may be approximately equal to the width of base member 2312. Many alternate configurations for complementary arrangement between the bottom of a construction panel frame and one or more sills are also possible, such as various tongue and groove combinations, multiple sills and complementary members, and other configurations. Sill member 2330 may be attached to base structure 2320 using a variety of attachment mechanisms. As shown, sill member 2330 is attached to base structure 2320 using an anchor 2321. Construction panel 2310 is attached to sill member 2330 using a variety of attachment mechanisms. As shown, construction panel 2310 is attached to sill member 2330 using a strap and fastener

attachment mechanism 2314, as described above with regard to Figures 21 and 22. Attachment mechanism 2314 attaches to a portion of base member 2312 and a portion of sill member 2330 and extends across the seam between them. A plurality of attachment mechanisms may be arranged along the length of a construction panel, as shown in Figure 24. Construction panel 2310 may also be attached to base structure 2320. Construction panel 2310 may be attached to base structure 2320 using a variety of attachment mechanisms. As shown, construction panel 2310 is attached to base structure 2320 using a strap and fastener attachment mechanism 2315. Attachment mechanism 2315 attaches to a portion of sill compliment member 2312 and a portion of base structure 2320 and extends across a seam between them. A plurality of attachment mechanisms may be arranged along the length of a construction panel. Attachment mechanisms for attaching construction panel 2310 to base structure 2320 and sill member 2330 may engage a portion of frame 2311 that is not covered by any surface covering layers. The attachment mechanisms may not be aesthetically desirable in the finished state. One or more base plates 2340 and 2341 may be installed to cover the exposed portion of frame 2311, sill member 2330, and various fastening mechanisms. Base plates 2340 and 2341 may include metal base plates, base board molding, hard rubber base plates, or other covers. Base plates 2340 and 2341 may be attached to construction panel 2310 and/or base structure 2320 using a variety of attachment mechanisms, such as fasteners, adhesives, or other attachment mechanisms.

Figure 24 shows a front view of adjacent construction panels 2410 and 2420 attached to a sill 2430. Construction panels 2410 and 2420 are attached to one another and sill 2430 using a plurality of strap and fastener attachment mechanisms 2430, 2431, 2432, 2433, and 2434.

Wire-based Subsystems

Any construction panel may have a portion of one or more building subsystems pre-installed within it. Pre-installed subsystems generally include one or more surface devices, one or more internal devices, and one or more connective devices. Surface devices include any device that extends through one or more surface covering layers of the construction panel. Surface devices are usually visible, though not necessarily obvious, on the surface of the finished construction panel. Internal devices include devices that are installed within the interior space of the construction panel and are generally not visible on the surface of a finished construction panel. Connective devices are devices used to interconnect other devices for the subsystem. Connective devices are installed within the interior space of the construction panel and may extend to an edge of the construction panel for interconnection with other portions of the subsystem. Some connective devices may by site-installed to interconnect portions of the subsystem in adjacent construction panels or building structures. In many cases, a connective device may be used to interconnect the pre-installed portions with a subsystem source of some kind.

Figure 25 shows an example wire-based subsystem 2500 with portions pre-installed in a number of adjacent construction panels. The construction panels are shown as frames only, without surface covering layers, in order to expose the internal devices and connective devices. The construction panels may include one or more surface covering layers. First construction panel 2510, second construction panel 2520, and third construction panel 2530 each include a frame comprised of a plurality of members. First construction panel 2510 may be attached to second construction panel 2520. Second construction panel 2520 may be attached to first construction panel 2510 and third construction panel 2530. Third construction panel 2530 may be attached to second construction panel 2520. Each of construction panels 2510, 2520, and 2530 may be attached to a sill 2540. Each of construction panels 2510, 2520, and 2530 may be attached to adjacent building structures (not shown), such as a base structure, adjacent walls or supports, or a ceiling. In each of construction panels 2510, 2520, and 2530, portions of the wire-based subsystem may be attached to the members of the frames. Attachment to the frame members may be accomplished in any number of ways, as appropriate to the subsystem and frame material. For example, a wire-based system installed in a construction panel with a wooden frame may employ fasteners to attach internal and surface devices and wire guides or staples for attaching connective wires to the frame. Portions of the subsystem, specifically the wires, may pass through one or more members of the frames. The frame members may define holes for

accommodating the wires. In some embodiment, holes in the frame members, such as members at the edge of the frame, may define guide conduits for site wiring portions of the subsystem. Frames may also be modified to accommodate or provide additional support for devices or portions of subsystems. For example, construction panel 2520 includes an additional member 2521 for securing a device. Other modifications are possible and may include adding members, removing members, moving members, using alternate materials, providing mounting devices and assemblies, or otherwise providing structure to secure portions of a subsystem. During fabrication of the construction panels and installation of the construction panels on-site, portions of the wire-based subsystem may be electrically connected. Being electrically connected includes providing conducting contact between portions of the subsystem. Conducting contact may not be direct contact. Conducting contact may include conduction through a series of intermediate devices or sub-portions of the subsystem. For example, in a completed circuit, all components may be regarded as electrically connected to each other component, including a circuit source. Within the context of wire-based subsystems within a building, each device in an electrical, communication, thermostat, security system, and other subsystems may be regarded as electrically connected if a conducting connection is provided between each adjacent component. The interruption in actual conductivity provided by switches, hubs, and similar components does not

impact the concept of electrical connection in the fabrication and installation of a wire-based subsystem.

Construction panel 2510 includes a first portion 2560 of wire-based subsystem 2500. First portion 2560 may include one or more devices for centralized directing, switching, and/or controlling other portions of wire-based subsystem 2500. For example, first portion 2560 may include an electrical box, a communications hub, central control for an alarm system, a master computer for a smart house, a network server, a central receiver or router for an audio/video/broadcast system, central control for an intercom, or another central control system for a building subsystem. First portion 2560 may include surface devices, internal devices, and connective wires for achieving its controlling function. For example, surface device 2561 may be a central control appliance, such as a switch, router, hub, computer, or other device. Surface device 2561 may include mechanical or electronic access to control functions. In a preferred embodiment, surface device 2561 is an electrical box for an electrical subsystem. In another preferred embodiment, surface device is a computer system and associated hardware for controlling the functions of multiple building functions. The computer system may direct communications and broadcast signals and control security systems, HVAC, networked appliances, and other house subsystems. Though only a single surface device 2561 is shown, a system of interconnected surface and internal devices may be employed for the control system. Other surface

devices unrelated to central control may also be included in subsystem portion 2560, such as outlets, fixtures, or appliances. First portion 2560 also includes junction boxes 2562 and 2563. Junction boxes 2562 and 2563 allow first portion 2560 to be electrically connected to subsystem portion outside construction panel 2510. Junction boxes 2562 and 2563 may be any type of device for housing a connection between two or more wires. In one embodiment, junction boxes 2562 and 2563 may include open boxes with access points for threading wires into the box, where they may be manually connected to other wires. In an alternate embodiment, junction boxes 2562 and 2563 may include interconnected hardware receptors accommodating connectors attached to the ends of the wires to be connected. Junction boxes 2562 and 2563 may not connect wires in a one-to-one ratio from the construction panel to wires outside the construction panel. For example, a junction box may accommodate a single input wire and electrically connect it to multiple wires internal to the construction panel. In a preferred embodiment, junction boxes 2562 and 2563 are accessible during installation of construction panel 2510 such that wires from other portions of subsystem 2500 may be connected to first portion 2560 and those connection may be inspected. Surface device 2561 is connected to junction boxes 2562 and 2563 by internal wires 2564, 2565, 2566, 2567, and 2568. In one embodiment, surface device 2561 is a control system for multiple wire-based subsystems and wires 2564, 2565, 2566, 2567, and 2568 may include different types of wire, such as electrical wire, telephone wire,

coaxial cable, speaker wire, etc., for the different subsystems. In a preferred embodiment, where subsystem 2500 is an electrical system, wire 2564 may be a source wire and each of wires 2565, 2566, 2567, and 2568 may be a different circuit for the building. Multiple wires may electrically connect first portion 2560 to the portions in other construction panels and/or in other building structures. In a preferred embodiment, these other wires are installed on-site. Source wire 2550 leads from junction box 2562 to a source 2551 for the wire-based system. Source 2551 may include an originating portion of subsystem 2500, such as a generator or other energy source. Source 2551 may include a connection to private or public distribution network, such as a power distribution line, telephone or other data line, satellite or terrestrial broadcast system, or other network. Wires 2552, 2553, 2554, and 2555 may connect to other portions of subsystem 2500. For example, wire 2552 may electrically connect wire 2565 to a portion of subsystem 2500 on the next floor up (not shown) in the building. Wire 2553 may electrically connect wire 2566 to portions of subsystem 2500 adjacent to construction panel 2510 opposite construction panel 2520 or elsewhere in the building. Wire 2554 may electrically connect wire 2567 to a second portion 2570 in construction panel 2520. Wire 2555 may electrically connect wire 2567 to portions of subsystem 2500 adjacent to construction panel 2530 opposite construction panel 2520 or elsewhere in the building. First portion 2560 may support any number of subsystem types and any number of connections with other subsystem portions.

Construction panel 2520 includes second portion 2570 of wire-based subsystem 2500. Second portion 2570 includes multiple surface devices for providing functional interactivity with subsystem 2500. Surface devices 2571 and 2572 may be any surface device appropriate to the subsystem type. For example, in an electrical system, surface device 2571 may be a switch and surface device 2572 may be an outlet. Other surface devices may include other types of outlets and switches, control panels, thermostats, intercoms, network devices, speakers, appliances, sensors, and other devices. Second portion 2570 may also include junction boxes 2573 and 2574. Junction boxes 2573 and 2574 may function similarly to junction boxes 2562 and 2563 described above. Wire 2575 may electrically connect surface device 2571 to junction box 2573. In one embodiment, where surface device 2571 is a switch, wire 2575 and any subsystem portion electrically connected to it through junction box 2573 may be switched by surface device 2571. Wire 2576 may electrically connect surface device 2571 to surface device 2572. Wire 2577 may electrically connect surface device 2572 to junction box 2574. Junction box 1573 may receive a wire 2555 for electrically connecting to an additional portion (not shown) of subsystem 2500. In one embodiment, the additional portion may be a light fixture, ceiling fan, or other surface device built into an adjacent horizontal construction panel (not shown). Where surface device 2571 is a switch, the light fixture, ceiling fan, or other surface device may be switched by surface device 2571. Junction box 2574 may receive wire 2554 to

electrically connect second portion 2570 to first portion 2560. Junction box 2574 may also receive a wire 2556 electrically connected to a third portion 2580 in construction panel 2530. This is a second example of a junction box that does not receive an equal number of interior and external wires or an equal number of input and output wires.

Construction panel 2530 includes third portion 2580 of wire-based subsystem 2500. Third portion 2580 includes multiple surface devices for providing functional interactivity with subsystem 2500. Surface devices 2581, 2582, 2583, and 2584 may be any surface devices appropriate to the subsystem type. For example, in an electrical system, surface device 2581 may be a light fixture, surface device 2582 may be a switch, surface devices 2583 and 2584 may be outlets. Surface device 2584 may be a combined surface device and junction box, such as an outlet with space to receive a wire and be inspected. Third portion 2580 may further incorporate a guide conduit 2585 for guiding a wire from the edge of construction panel 2530 to surface device 2584. Wire 2586 may electrically connect surface device 2581 to surface device 2582. In one embodiment, where surface device 2582 is a switch, surface device 2581 may be switched by surface device 2582. Wire 2587 may electrically connect surface device 2582 to surface device 2583. Wire 2588 may electrically connect surface device 2583 to surface device 2584. Surface device 2584 may receive wire 2556 to electrically connect third portion 2580 to second portion 2570.

Figure 26 shows a detailed view of system for site-wiring a construction panel 2610. Construction panel 2610 may by attached to a base structure 2630 using a sill 2640. Construction panel 2610 may be electrically connected to other portions of a subsystem by a connecting wire 2650. Construction panel 2610 includes a frame 2611 and surface covering layers 2612 and 2613. Frame 2611 includes a base member 2614 and a sill complimentary member 2615. Base member 2614 defines a hole 2616 for accommodating connecting wire 2650 from outside construction panel 2610. Frame 2611 also includes an additional member 2617 for securing a junction box 2620. Additional member 2617 defines a hole 2618 for accommodating an internal wire 2621. Junction box 2620 is electrically connected to internal wire 2621 that may be electrically connected to one or more surface devices or internal devices within construction panel 2610. Construction panel 2610 may be attached to sill 2640. Base member 2614 and sill complimentary member 2615 may mate with sill 2640 and one or more attachment mechanisms may be used to attach construction panel 2610 to sill 2640, as described above. Sill 2640 may define an opening 2641 for accommodating connecting wire 2650. A second connecting wire 2651 may run parallel to connecting wire 2650 and electrically connect other portions of a wire-based subsystem. Connecting wires 2650 and 2651 may be accommodated within a space defined by base member 2614, sill 2640, and the width of surface covering layer 2612. A first base plate 2660 may be installed to cover access to junction box 2620

and the space accommodating connecting wires 2650 and 2651. When installed, first base plate 2660 may extend vertically from base structure 2630 and overlap a portion of surface covering layer 2612. A second base plate 2661 may be installed on the opposite side of construction panel 2610.

Figure 27 shows a method of installing a panelized construction system with at least one wire-based subsystem preinstalled in the panels. In step 2710, a construction panel including a portion of a wire-based subsystem, such as one of construction panels 2510, 2520, or 2530 from Figure 25, is positioned. The portion of the wire-based subsystem may include surface devices, internal devices, and/or connective devices. The construction panel may include one or more receptors for attaching one or more connecting wires. For example, the construction panel may include one or more junction boxes, with or without guide conduits, accessible from an edge of the construction panel. The construction panel may be positioned in accordance with predetermined building configuration. For example, a vertical construction panel may be positioned along a sill attached to a base structure in a particular configuration. Horizontal or pitched construction panels may be positioned between two support structures, such as vertical panels, ridge beams, or bearing ledgers. In step 2720, the positioned construction panel is fixed in place. The construction panel may be attached to adjacent construction panels or building structures using a variety of attachment mechanisms. The construction panel may be attached to a sill and/or a base structure, or another support. Steps 2710 and

2720 may be repeated for a plurality of construction panels. In step 2730, a connecting wire is run to the positioned construction panel or panels. The connecting wire may be run through a space adjacent the construction panel frame. The connecting wire may be inserted into a guide conduit leading to a junction box or other receptor for the connecting wire. Alternatively, where there is access to a surface device or an internal device, such as when the construction panel has a side without a surface covering layer, the connecting wire may be run adjacent the construction panel directly to a receptor for the surface or internal device. In step 2740, the connecting wire is electrically connected to the subsystem portion in one or more construction panels. The connecting wire may be attached directly to connective devices, such as internal wires for the construction panel, within a receptor, such as a junction box. Alternatively, the receptor may accept the connecting wire and provide a hardware connection to the subsystem portion within the construction panel. In some cases, both ends of the connecting wire may be connected to subsystem portions within the construction panel. Alternatively, one end may have been previously connected or be part of a pre-existing building subsystem. Steps 2730 and 2740 may be repeated for multiple connecting wire. In step 2750, the subsystem portion is electrically connected to a source for the subsystem. Electrically connecting to the source may include connecting a connecting wire to pre-existing portion of the subsystem, connecting to a newly installed source, or connecting to a source wire for a public or private distribution

system. In some cases, connecting to the source may be accomplished through steps 2730 and 2740 where one of the connecting wires run and connected is already electrically connected to the source. In step 2760, any exposed connecting wires and receptors are covered. Covering the connecting wires and receptors may include installing covers over open junction boxes, such as surface device face plates. Covering the connecting wires and receptors may include installing base plates or other covering panels over the spaces in which the connecting wires were run. Where the connecting wires run along the base of the construction panels and the receptors are immediately adjacent the construction panel base, a single base plate may be installed to cover both. Installing the base plate may include positioning and attaching the base plate to the construction panels. In some embodiments, construction panels may have operable covers preinstalled adjacent the receptors and/or the spaces for the connecting wires. Covering the connecting wires and receptors may include closing the preinstalled covers. In step 2770, the connections between the connecting wires and the subsystem portions pre-installed in the construction panels may be inspected by an individual of relevant experience or authority. In this way, quality and safety of subsystem connections may be evaluated and controlled. In some jurisdictions, inspections may be mandated by building code or other regulatory action. The method promotes for pre-installation of the majority of the subsystem in the construction panel to minimize on-site labor, while allowing for appropriate on-site inspection of the subsystem.

Mechanical Sub-systems

Many of the same principals from pre-installation of wire-based subsystems apply to the fabrication and installation of construction panels with mechanical subsystems. However, mechanical systems, such as heating, ventilation, and air conditioning systems, gas and vacuum systems, and other mechanical systems, utilize piping, ductwork, or other conduits. Generally, these conduits occupy more space than wires, are more time consuming to site install, and require greater mechanical precision to interconnect. Portions of a mechanical subsystem may be functionally connected. Functional connection is determined by the function of the particular subsystem. In many cases, functional connection includes mating compatible conduits or mating conduits to surface devices or internal devices. Functional connection may also include bonding and ensuring a seal between the mated devices. In some cases, mating of compatible devices may be approximate and additional material may be used to provide the seal, producing a functional connection. Functional connection may also be used to refer to the connection between two components where the two components are separated by one or more intermediate components, yet the two components may exchange material or otherwise function according to their intended purpose. For example a surface device, such as a vent, and a source, such as a furnace, may be separated by a considerable number of conduits (such as duct sections). However, they may still be regarded as functionally connected to one another.

Figure 28 shows an example of a portion of a mechanical subsystem 2800 preinstalled in adjacent construction panels. Construction panel 2810 and construction panel 2820 are adjacent horizontal construction panels. Construction panels 2810 and 2820 include frames 2811 and 2821. Only a relevant portion of frames 2811 and 2821 are depicted in Figure 28. Construction panels 2810 and 2820 are not shown with surface covering layers in order to better show the portion of the mechanical subsystem preinstalled within them. Construction panels 2810 and 2820 may include one or more surface covering layers on one or both sides as described above with reference to Figures 1-16. Frame 2811 of construction panel 2810 and frame 2821 of construction panel 2820 define a seam 2830 along their adjacent edges. Conduits within construction panels 2810 and 2820 may be shown intersecting frames 2811 and 2821. Openings in the members of frames 2811 and 2821 accommodate such conduits and allow them to pass uninterrupted through the frame members.

Construction panel 2810 includes a first portion 2840 of mechanical subsystem 2800. First portion 2840 provides for functional connection to a source 2850. First portion 2840 includes a first conduit 2841 for connecting to source 2801 and a second conduit 2851 for connecting to source 2801. Connecting devices 2841 and 2851 may include multiple sections of interconnected conduit. Conduit 2841 includes a surface device 2842 for mating with a conduit (not shown) from source 2801. Conduit 2841 includes a first redirecting joint (not shown)

connected to surface device 2842. The first redirecting joint alters the direction of conduit 2841 from perpendicular to the surface of construction panel 2810 to parallel to the surface of construction panel 2810 and seam 2830. The first redirecting joint connects to a first shaft portion 2843 parallel to seam 2830. First shaft portion 2843 extends to a second redirecting joint 2844 for altering the direction of conduit 2841 from parallel to seam 2830 to perpendicular seam 2830. Second redirecting joint 2844 connects to a second shaft portion 2845 perpendicular to seam 2830. Second shaft portion 2845 extends to seam 2830 where it mates with a second portion 2860 of mechanical subsystem 2800. Conduit 2851 includes a surface device 2852 for mating with a conduit (not shown) from source 2801. Conduit 2851 includes a first redirecting joint (not shown) connected to surface device 2852. The first redirecting joint alters the direction of conduit 2851 from perpendicular to the surface of construction panel 2810 to parallel to the surface of construction panel 2810 and seam 2830. The first redirecting joint connects to a first shaft portion 2853 parallel to seam 2830. First shaft portion 2853 extends to a second redirecting joint 2854 for altering the direction of conduit 2851 from parallel to seam 2830 to perpendicular seam 2830. Second redirecting joint 2854 connects to a second shaft portion 2855 perpendicular to seam 2830. Second shaft portion 2855 extends to seam 2830 where it mates with a second portion 2860 of mechanical subsystem 2800. In a preferred embodiment, source 2801 may be HVAC unit with output conduit and a return conduit. Conduit 2841

may be ductwork functionally connected to the return conduit. Conduit 2851 may be ductwork functionally connected to the output conduit.

Construction panel 2820 includes second portion 2860 of mechanical subsystem 2800. Second portion 2860 provides functional connection between a plurality of other portions, including first portion 2840. Second portion 2860 includes a first conduit 2861 and a second conduit 2871. Conduit 2861 may interconnect conduit 2851 from construction panel 2810, additional portions in adjacent horizontal panels (not shown), and additional portions in adjacent vertical panels (such as shown in Figure 29 below). Conduit 2871 may interconnect conduit 2841 from construction panel 2810 and additional portions in adjacent horizontal panels (not shown). Conduit 2861 includes a first shaft portion 2862 extending from an edge of construction panel 2820 at seam 2830 to a junction portion 2863. First shaft portion 2862 functionally connects to conduit 2851 at seam 2830. For an example of a connection between conduit 2851 and 2861, see description below regarding Figure 30. First shaft portion 2862 extends perpendicular to seam 2830. Junction portion 2863 may connect first shaft portion 2862 to second shaft portion 2864 and third shaft portion 2865. Second shaft portion 2864 extends perpendicular to first seam 2830, continuing first shaft portion 2862. Second shaft portion 2864 extends to an edge 2822 of construction panel 2820 opposite seam 2830. Second shaft portion 2864 may mate with additional portions of subsystem 2800 (not shown) at edge 2822. Third shaft portion 2865

extends parallel to seam 2830 from junction portion 2863 to a first redirecting joint 2866. First redirecting joint 2866 redirects conduit 2861 from a direction parallel to a surface of construction panel 2820 to perpendicular to a surface of construction panel. First redirecting joint (not shown) functionally connects third shaft portion 2865 to a surface device 2866. Surface device 2866 may define an opening in a surface of construction panel 2820 for mating with a conduit. The opening defined by surface device 2866 may mate with an opening in a top edge of a vertical construction panel, such as construction panel 2910 in Figure 29 and conduit 2921. For an example of a connection between surface device 2866 and conduit 2921, see the description of Figure 31 below. In an alternate embodiment, surface device 2866 may be a vent, register, or other surface device for mechanical system 2800. Conduit 2871 extends from seam 2830 to edge 2822, perpendicular to both seam 2830 and edge 2822. Conduit 2871 mates with conduit 2841 at seam 2830 and may mate with additional portions of subsystem 2800 at edge 2822.

Figure 29 shows a vertical construction panel 2910 with a portion 2920 of a mechanical subsystem, such as subsystem 2800 in Figure 28. Construction panel 2910 includes a frame 2811. Construction panel 2811 may include one or more surface covering layers (not shown). For further description of construction panels, see the description for Figures 1-16 above. Construction panel 2910 includes a portion 2920 of a mechanical subsystem. Portion 2920 includes a conduit 2921. Conduit 2921 extends from a top edge 2912 of construction panel 2910 to a surface

device 2925. Arrow 2022 indicated a direction of connection to an adjacent construction panel or other conduit. Conduit 2921 defines an opening at top edge 2912 that may mate with a conduit or a surface device from an adjacent horizontal panel, such as construction panel 2820 and surface device 2866 shown in Figure 28. Further description of an example connection between conduit 2921 and a surface device, such as surface device 2866, is provided below with regard to Figure 31. Conduit 2921 includes a shaft portion 2923 that extends from top edge 2912 parallel to a surface of construction panel 2910. Shaft portion 2923 connects to a redirecting joint (not shown). The redirecting joint changes the direction of conduit 2921 from parallel to the surface of construction panel 2910 to perpendicular to the surface of construction panel 2910. Conduit 2921 connects to surface device 2925 adjacent the redirecting joint. Surface device 2925 may include any surface device for a mechanical system. In a preferred embodiment, conduit 2921 is duct work for an HVAC system and surface device 2925 is a vent.

Figure 30 shows a connection between conduits 3040 and 3050 in adjacent construction panels 3010 and 3020. For example, the connection shown in Figure 30 may be a connection between the subsystem portions 2840 and 2860 in horizontal construction panels 2810 and 2820 in Figure 28. Only a small portion of construction panels 3010 and 3020 are shown. Construction panel 3010 includes a frame 3011. Frame 3011 includes an opening 3012 in members 3013 and 3014. Opening 3012 accommodates conduit 3040 where it extends to an edge 3015 of

construction panel 3010. Construction panel 3020 includes a frame 3021. Frame 3021 includes an opening 3022 in members 3023 and 3024. Opening 3022 accommodates conduit 3050 where it extends to an edge 3025 of construction panel 3020. Where frame 3011 of construction panel 3010 and frame 3021 of construction panel 3020 are adjacent, a seam 3030 is defined. Conduit 3040 of construction panel 3010 may be ductwork with a rectangular cross-section. Conduit 3040 may include a first wall 3041, a second wall 3042, a third wall 3043, and a fourth wall (not shown). Each wall may define a lip, such as lip 3044 of first wall 3041 and lip 3045 of second wall 3042, extending beyond edge 3015. In some embodiments, lips 3044 and 3045 may be attached to member 3014 using fasteners or other attachment mechanisms. Conduit 3050 of construction panel 3020 may also be ductwork with a rectangular cross-section. Conduit 3050 may include a first wall 3051, a second wall 3052, a third wall 3053, and a fourth wall (not shown). Each wall may define a lip, such as lip 3054 of first wall 3051 and lip 3055 of second wall 3052, extending beyond edge 3025. In some embodiments, lips 3054 and 3055 may be attached to member 3024 using fasteners or other attachment mechanisms. Attachment mechanisms may be provided for attaching conduit 3040 to conduit 3050. In some embodiments, the attachment mechanism may include a seal 3031, such as an adhesive sealing ring. In some embodiments, once conduits 3040 and 3050 are mated to each other attachment of adjacent construction panels 3010 and 3020 may be sufficient to provide functional

connection of conduits 3040 and 3050. In other embodiments, one or both of conduits 3040 and 3050 may include a collar or other portion for extending from one conduit, across seam 3030, and into the other conduit. A collar or other extensions may or may not be attached to the opposite conduit.

Figure 31 shows a connection between a surface device 3140 and a conduit 3150 in adjacent construction panels 3110 and 3120. For example, the connection shown in Figure 31 may be a connection between subsystem portion 2860 in horizontal construction panels 2820 in Figure 28 and subsystem portion 2920 in vertical construction panel 2910 in Figure 29. Only a small portion of construction panels 3110 and 3120 are shown. Construction panel 3110 includes a frame 3111 and a surface covering layer 3112. Surface covering layer 3112 defines an opening 3113. Opening 3113 accommodates surface device 3140 where it extends through a surface 3115 of construction panel 3110. Construction panel 3120 includes a frame 3121. Frame 3121 includes an opening 3122 in members 3123 and 3124. Opening 3122 accommodates conduit 3150 where it extends to an edge 3125 of construction panel 3120. Where surface covering layer 3112 of construction panel 3110 and frame 3121 of construction panel 3120 are adjacent, a seam 3130 is defined. Surface device 3140 of construction panel 3110 may be ductwork with a rectangular cross-section for connecting to adjacent ductwork. Surface device 3140 may be continuous with a conduit 3145. Conduit 3145 may be ductwork with a rectangular cross-section extending parallel to surface covering layer 3112.

Conduit 3145 may include a redirecting joint 3146 for connecting to Surface device 3140, which is perpendicular to surface covering layer 3112. Surface device 3140 may include a first wall 3141, a second wall 3142, a third wall 3043, and a fourth wall (not shown). Each wall may define a lip, such as lip 3144 of first wall 3141 and lip 3145 of second wall 3142, extending beyond surface 3115. In some embodiments, lips 3144 and 3145 may be attached to surface covering layer 3112 using fasteners or other attachment mechanisms. Conduit 3150 of construction panel 3120 may also be ductwork with a rectangular cross-section. Conduit 3150 may include a first wall 3151, a second wall 3152, a third wall 3153, and a fourth wall (not shown). Each wall may define a lip, such as lip 3154 of first wall 3151 and lip 3155 of second wall 3152, extending beyond edge 3125. In some embodiments, lips 3154 and 3155 may be attached to member 3124 using fasteners or other attachment mechanisms. Attachment mechanisms may be provided for attaching surface device 3140 to conduit 3150. In some embodiments, the attachment mechanism may include a seal 3131, such as an adhesive sealing ring. In some embodiments, once surface devices 3140 is mated to conduit 3150, attachment of adjacent construction panels 3110 and 3120 may be sufficient to provide functional connection of conduits 3140 and 3150. In other embodiments, one or both of surface devices 3140 and conduit 3150 may include a collar or other portion for extending from one conduit, across seam 3130, and into the other

device. A collar or other extensions may or may not be attached to the opposite conduit.

Figure 32 is a flow chart describing an example method if installing a panelized construction system with built-in mechanical subsystems. In step 3210, a construction panel with built-in internal conduits is positioned. The construction panel includes a portion of a mechanical subsystem. The portion of the mechanical subsystem includes a conduit extending to an edge or a surface of the construction panel such that the conduit is accessible from outside the construction panel. In some embodiments, the construction panel may be positioned according to a pre-determined building configuration. Positioning the construction panel may include positioning a vertical construction panel on a base structure. For example, a wall panel may be positioned according to the location of a previously installed sill. Positioning the construction panel may include positioning a horizontal or pitched construction panel on two or more support structures. For example a horizontal construction panel may be positioned atop two wall panels or between two support ledgers. As another example, a pitched construction panel may be positioned between a the top of a wall panel and a ridge beam or support ledger. The construction panel may be positioned adjacent a source for the mechanical subsystem, such as a furnace, HVAC unit, or other source. The construction panel may be positioned adjacent a conduit to a pre-existing or pre-installed portion of the mechanical subsystem that includes a source for the mechanical subsystem. In step

3220, the positioned construction panel is fixed in place. The construction panel may be attached to adjacent construction panels or building structures using a variety of attachment mechanisms. In step 3230, a conduit external to the construction panel is engaged to the internal conduit built-into the construction panel. Engaging the external conduit may include mating compatible openings in the external conduit and internal conduit to form a functional connection. Engaging the external conduit may include providing a seal between the external conduit and the internal conduit. The external conduit may be a conduit functionally connected to a source for the mechanical system. The external conduit may be a portion of a pre-existing mechanical system. The external conduit may be a portion of a mechanical system built-into an adjacent building structure, such as a pre-existing wall or an adjacent construction panel. The external conduit may be engaged to the internal conduit by virtue of the positioning and attachment of the construction panel. For example, the external conduit may be built-into an adjacent building structure and positioning the construction panel may include mating the external conduit to the internal conduit. In step 3240, an additional construction panel with an internal conduits is placed adjacent a previously placed construction panel, such as the construction panel positioned in step 3210. In step 3250, the internal conduit of the adjacent construction panels are engaged. In step 3260, the newly placed construction panel is attached to the previously placed construction panel and other adjacent building structures. Steps 3240 though 3260 may be repeated for as many

additional construction panels as are to be placed. The order in which multiple construction panels are positioned and attached may be determined by a number of factors. For example, where some of the construction panels provide the base structure or support structure for other panels, the supporting panels may be placed first. Placement of a construction panel attached to the source may be made at any point during the sequence of placing the multiple construction panels. Further, all or a sub-set of the construction panels may be positioned and attached prior to connecting the subsystem portion built into the construction panels to other portions of the subsystem, such as the subsystem portion including the source. Connection of the subsystem portion built-into the construction panels to another subsystem portion may be a later step where the connection point for the internal conduit remains accessible in spite of placement of the other construction panels.

Industrial and Commercial Systems

Figures 33-44 relate to systems and methods of adapting panelized construction techniques to commercial, industrial, and other buildings with different structural, organizational, and installation considerations. Largely, panelized construction for commercial and industrial buildings follows the same systems and methods as residential buildings. The description above for Figures 1-24, regarding construction panels, attachment mechanisms, and systems and methods for their use applies to use in commercial and industrial buildings as well. Commercial and industrial building may have some different considerations with

regard to material and structural considerations. For example, many commercial and industrial structures may need to meet greater load bearing requirements. Some commercial and industrial building configurations may reflect different priorities regarding the selection of both frame materials and surface layer materials. For example, commercial and industrial frames may be more likely to be constructed of larger wood members, light gage structural metal members, pre-cast concrete, etc. Commercial and industrial building panels are more likely to be fabricated with heavier surface covering materials, such as 5/8" gypsum board, metal roofing and siding, and other materials. Commercial and industrial buildings may also be more amenable to prefabrication as larger panels. Builders of commercial and industrial building are more likely to have access to the equipment and manpower required for maneuvering and installing larger construction panels. Greater economy may be achieved through the prefabrication of larger construction panels, as long as they do not exceed sizes that may b reasonably transported and installed. Construction panels for commercial and industrial building modules may include any number of pre-installed building subsystems, such as electrical and mechanical subsystems. The systems and methods described above with regard to Figures 25-32 apply to such subsystems in commercial and industrial building panels as well. In addition to portions of building subsystems, the interior spaces of commercial and industrial construction panels may include core materials.

Figures 33-35 show several example vertical panel configurations for use in commercial and industrial buildings. Figure 36 shows a cross-section of a commercial or industrial building module showing how a variety of building panels may be used in constructing a commercial or industrial building. Figures 37-41 shows a variety of example attachment mechanisms for application in commercial and industrial buildings. Note that these attachment mechanisms may also be used in many building configurations, including residential buildings. Figures 42 and 43 show two building configurations depicting the versatility of commercial and industrial building layouts. Figure 44 is a flowchart describing an example method of installing a commercial or industrial building using panelized construction systems and methods.

Figures 33-35 show three different construction panel configurations for use in commercial and industrial buildings. Figures 33 and 34 show front views of vertical construction panel frames, such as for use as wall panels in a commercial or industrial building. Figure 35 shows a side view of a vertical construction panels for use in a commercial or industrial building.

Figure 33 depicts a construction panel 3300. Construction panel 3300 includes a frame 3310 and two bearing ledgers 3320 and 3330. Frame 3310 includes a rectangular outer frame 3311. Outer frame 3311 includes top members 3312 and 3313 and base members 3314 and 3315. Outer frame 3311 also includes side members 3316 and 3317. Outer frame 3311 defines a plurality of edges for

attaching construction panel 3300 to adjacent structures. Frame 3310 also includes stud members 3318 and 3319. Frame 3310 defines a front surface and a back surface for supporting surface covering layers. The dimensions of frame 3310 are determined by the building configuration in which construction panel 3300 is to be used. In one embodiment, frame 3310 is up to 20' high and up to 4' wide. The spacing between stud members 3318 and 3319 and side members 3316 and 3317 may be determined by the structural requirements of the building and applicable building codes. Construction panel 3300 may be configured to be a bearing wall, shear wall, fire-rated wall, exterior wall, interior wall, or any other configuration. In one embodiment, the vertical members are spaced less than 16" apart. Construction panel 3300 includes two bearing ledgers 3320 and 3330. In a preferred embodiment, bearing ledger 3320 would support a horizontal roof construction panel. Bearing ledger 3330 would support a horizontal ceiling construction panel. In this building configuration, the area below bearing ledger 3330 would define an interior usable space of the building, the area between the bearing ledger 3320 and bearing ledger 3330 would define an interior attic crawlspace for housing storage or building subsystems, and the area above bearing ledger 3320 would define a flat roof with parapet walls. Bearing ledgers 3320 and 3300 may be made of a single lateral member or a composite lateral member. Bearing ledgers 3320 and 3330 may be made of any of the materials that frames may be made of, such as wood, steel, or other materials. Bearing ledgers and the

frames to which they are attached need not be composed of the same materials. Bearing ledgers 3320 and 3330 may define a space (not shown) for accommodating a complementary portion of a horizontal or pitched construction panel or an attachment mechanism for connecting to a horizontal or pitched construction panel. Bearing ledgers 3320 and 3330 may be attached to frame 3310 using any attachment mechanism, such as fasteners, welds, and other attachment mechanisms. Further examples of bearing ledgers and their use are described below with regard to Figures 38 and 39.

Figure 34 shows an alternate construction panel configuration include a prefabricated truss support for pitched construction panels. Construction panel 3400 includes a frame 3410 and a bearing ledger 3450. Frame 3410 includes a rectangular outer frame 3411 and a truss frame 3430. Rectangular outer frame 3411 is defined by top members 3412 and 3413, bottom members 3414 and 3415, and side members 3416 and 3417. Truss frame 3430 includes pitched members 3431 and 3432 and truss plates 3433, 3434, and 3435. Frame 3410 includes stud members 3418, 3419, 3420, 3421, 3422, 3423, 3424, and 3425 extending from base member 3414 to top member 3413 and truss stud members 3436, 3437, 3438, 3439, 3440, 3441, 3442, and 3443. In one embodiment, frame 3410 may be up to 25' wide, rectangular frame 3411 may be up to 20' high, and the total frame height may be up to 25'. Truss frame 3430 may support a pitched roof, such as a rood comprised of a plurality of pitched construction panels. Construction panel 3400

includes a single bearing ledger 3450. In one embodiment, the area below bearing ledger 3450 defines an internal building space and the area between bearing ledger 3450 and the top of frame 3410 may be a finished or unfinished attic area. Construction panel 3400 may be fabricated out of a variety of the materials, as described above.

Figure 35 shows a side cross-sectional view of a construction panel 3500. Construction panel 3500 includes a frame 3510, a first surface covering layer 3520, a second surface covering layer 3521, a third surface covering layer 3522, a core layer 3530, and a bearing ledger 3540. Frame 3510 includes a plurality of horizontal members, including top members 3511 and 3512 and base members 3513 and 3514. Frame 3510 may also include a plurality vertical members, such as side members (not shown) and stud members (not shown). Frame 3510 defines a first surface 3515 and a second surface 3516 on opposite sides. Frame 3510 supports surface covering layers 3520, 3521, and 3522. Variations in the number of surface covering layers are possible. The surface above bearing ledger 3540 and below bearing ledger 3540 may include different numbers and/or materials for the surface covering layers. Surface covering layers 3520, 3521, and 3522 may include a variety of materials as described above. For example, surface covering layers 3520, 3521, and 3522 may all be ½" drywall of first surface covering layer 3520 may be metal siding, second surface covering layer 3521 may be exterior sheathing, and surface covering layer 3522 may be ¾" gypsum board. As shown, base

members 3513 and 3514 define a space for accommodating a sill for attaching construction panel 3500 to a base structure. The vertical members define spaces for accommodating core layer 3530. Core layer 3530 may include a variety of materials. For example, core layer 3530 may be insulation.

Figure 36 is a cross-section of an example building 3600 constructed using a plurality of pre-fabricated construction panels. Building 3600 may be a commercial, industrial, or other type of building. Building 3600 includes a base structure 3610, a first wall panel 3620, a second wall panel, 3630, a floor panel 3640, a ceiling panel 3650, a roof panel 3660, a wire-based subsystem 3670, and a mechanical subsystem 3680. Base structure 3610 may define at least a portion of a basement for building 3600. First wall panel 3620 may define at least a portion of a front wall of building 3600. Additional construction panels (not shown) positioned adjacent to first wall panel 3620 may further define the front wall of building 3600. Second wall panel 3630 may define at least a portion of a rear wall of building 3600. Additional construction panels (not shown) positioned adjacent to second wall panel 3630 may further define the rear wall of building. Building 3600 may also include side walls (not shown) comprised of one or more construction panels. First wall panel 3620, second wall panel 3630, and one or more side walls may define a bay of predetermined size. Building 3600 may include a plurality of bays. Figures 42 and 43 below provide some example layouts of panelized buildings including multiple bays. Floor panel 3640 may define at least a portion of a floor

of building 3600 and a ceiling for the basement of building 3600. Additional construction panels (not shown) adjacent to floor panel 3640 may further define the floor of building 3600. Ceiling panel 3650 may define at least a portion of a ceiling of building 3600 and a floor for an attic space of building 3600. Additional construction panels (not shown) adjacent to ceiling panel 3650 may further define the ceiling of building 3600. Roof panel 3660 may define at least a portion of a roof for building 3600 and a ceiling for an attic space of building 3600. Additional construction panels (not shown) adjacent ceiling panel 3650 may further define the roof of building 3600.

Base structure 3610 may provide a foundation for supporting building 3600. For example, base structure 3610 may be a site poured cement foundation. Base structure 3610 may support one or more walls or floors. As shown, base structure 3610 supports first wall panel 3620, second wall panel 3630, and floor panel 3640. Base structure 3610 may include a foundation floor 3611, a first foundation wall 3612, and a second foundation wall 3613. Base structure 3610 may also include additional foundation walls (not shown) to further define a configuration for building 3600. Base structure 3610 may further include a variety of supports and attachment mechanisms for supporting and attaching to additional structures. For example, base structure 3610 includes a first bearing ledger 3614, a second bearing ledger 3615, and a support beam 3616 for supporting floor panel 3640. Base structure 3610 may include attachment mechanisms, including fasteners, sills, and

other attachment mechanism components within the base structure material. Base structure 3610 may also define spaces for accommodating portions of one or more building subsystems.

First wall panel 3620 is a vertical construction panel. First wall panel 3620 is supported by and attached to base structure 3610 adjacent first foundation wall 3612. An example attachment mechanism is shown in Figure 41. First wall panel 3620 includes a frame 3621, a first surface covering layer 3622, a second surface covering layer 3623, a third surface covering layer 3624, a first interior bearing ledger 3625, and a second interior bearing ledger 3626. First wall panel 3620 may also include one or more built-in features (not shown). For example, first wall panel 3620 may include a door and several windows. Frame 3621 may include a plurality of members (not shown). Frame 3621 may provide support for surface covering layers 3622, 3623, and 3624 and bearing ledgers 3625 and 3626. First wall panel 3620 supports an end portion of ceiling panel 3650 and roof panel 3660. Ceiling panel 3650 is supported by and attached to bearing ledger 3625. Roof panel 3660 is supported by and attached to bearing ledger 3626. Example attachment mechanisms are shown in Figures 38 and 39. Frame 3621 and third surface covering layer 3624 define spaces for accommodating a portion of one or more building subsystems. First wall panel 3620 may also include an exterior bearing ledger 3627 and exterior feature 3628. For example, exterior feature 3628 may be a panelized canopy, soffit, sign or sign mounting, marquee, or other feature.

Exterior feature 3628 may be supported by and attached to exterior bearing ledger 3627 using any attachment mechanism.

Second wall panel 3630 is a vertical construction panel. Second wall panel 3630 is supported by and attached to base structure 3610 adjacent second foundation wall 3613. An example attachment mechanism is shown in Figure 41. Second wall panel 3630 includes a frame 3631, a first surface covering layer 3632, a second surface covering layer 3633, a third surface covering layer 3634, a first interior bearing ledger 3635, and a second interior bearing ledger 3636. Second wall panel 3630 may also include one or more built-in features (not shown). For example, second wall panel 3630 may include a pair of rear utility doors. Frame 3631 may include a plurality of members (not shown). Frame 3631 may provide support for surface covering layers 3632, 3633, and 3634 and interior bearing ledgers 3635 and 3636. Second wall panel 3630 supports an end portion of ceiling panel 3650 and roof panel 3660, opposite the end portions supported by first wall panel 3620. Ceiling panel 3650 is supported by and attached to bearing ledger 3635. Roof panel 3660 is supported by and attached to bearing ledger 3636. Example attachment mechanisms are shown in Figures 38 and 39. Frame 3631 and third surface covering layer 3634 define spaces for accommodating a portion of one or more building subsystems.

Floor panel 3640 is a horizontal construction panel. Floor panel 3640 is supported by bearing ledgers 3614 and 3615 and support beam 3616 of base

structure 3610. Floor panel 3640 includes a frame 3641, a first surface covering layer 3642, and a second surface covering layer 3643. Frame 3641 may include a plurality of members (not shown). Frame 3641 may include any of a variety of materials, as described above. For example, frame 3641 may comprise a plurality of 2x12 wood joists, steel bar joists, prefabricated I joists, or a structural steel shape. Surface covering layers 3642 and 3643 may include any of a variety of materials, as described above. For example, first surface covering layer 3642 may include sheets of under flooring and second surface covering layer 3643 may include steel deck sheathing or concrete topping. In an alternate embodiment, floor panel 3640 may include a third surface covering layer disposed on the lower surface of frame 3641, such as dry wall or gypsum board. Frame 3641 may define spaces for accommodating portions of one or more building subsystems.

Ceiling panel 3650 is a horizontal construction panel. Ceiling panel 3650 is supported by bearing ledgers 3625 of first wall panel 3620 and bearing ledger 3635 of second wall panel 3630. Ceiling panel 3650 includes a frame 3651 and a surface covering layer 3652. Frame 3651 may include a plurality of members (not shown). Frame 3651 may include any of a variety of materials, as described above. Surface covering layer 3652 may also include any of a variety of materials, as described above. For example, first surface covering layer 3652 may include drywall or gypsum board. In an alternate embodiment, ceiling panel 3650 may include another surface covering layer disposed on the upper surface of frame 3651. Frame

3651 and surface covering layer 3652 may define spaces for accommodating portions of one or more building subsystems.

Roof panel 3660 is a horizontal construction panel. Roof panel 3660 is supported by bearing ledgers 3626 of first wall panel 3620 and bearing ledger 3636 of second wall panel 3630. Roof panel 3660 includes a frame 3661 and a surface covering layer 3662. Frame 3661 may include a plurality of members (not shown). Frame 3661 may include any of a variety of materials, as described above. Surface covering layer 3662 may also include any of a variety of materials, as described above. For example, first surface covering layer 3662 may include exterior sheathing for supporting an appropriate roofing material. The roofing material may be preinstalled on first surface covering layer 3662. In an alternate embodiment, roof panel 3660 may include another surface covering layer disposed on the lower surface of frame 3661, such as dry wall or gypsum board. Frame 3661 may define spaces for accommodating portions of one or more building subsystems.

Wire-based subsystem 3670 may be substantially as the wire-based subsystems described above. Wire-subsystem 3670 may include a source wire 3671 electrically connecting an outside source to a first portion 3672 in floor panel 3640. A first connecting wire 3673 may connect first portion 3672 to a second portion 3674 in first wall panel 3620. A second connecting wire 3675 may electrically connect a third portion 3676 in second wall panel 3630 to a source. Second connecting wire 3675 may connect through other portions (not shown) to

first portion 3672 or second portion 3674. A third connecting wire 3677 may connect to a fourth portion 3678 in ceiling panel 3650. Each portion may include one or more surface devices providing subsystem access within building 3600.

Mechanical subsystem 3680 may be substantially as the mechanical subsystems described above. Mechanical subsystem 3680 may include a source 3681. For example, source 3681 may be a roof mounted HVAC unit. Source 3681 is functionally connected to a first portion 3682 in roof panel 3660. First portion 3682 may be functionally connected to a second portion 3684 in ceiling panel 3650 by an external conduit 3683. Second portion 3684 may include one or more surface devices for providing subsystem access within building 3600. A plurality of additional portions (not shown) may further distribute mechanical subsystem 3680 throughout building 3600.

Figure 37 shows an example attachment mechanism 3700 for attaching a first construction panel 3710 to an adjacent second construction panel 3720. First construction panel 3710 and second construction panel 3720 are positioned adjacent each other such that an edge 3711 of first construction panel 3710 and an edge 3721 of second construction panel 3720 form a seam 3730. A seal 3731 may be provided along seam 3730. A strap 3740 may be positioned across seam 3730 on adjacent surface 3712 of first construction panel 3710 and surface 3722 of second construction panel 3720. Strap 7340 is attached to first construction panel 3710 using fastener 7341. Strap 7340 is attached to second construction panel 3720

using fastener 7342. Additionally, an angled fastener 7343 may be directed through second construction panel 3720 into first construction panel 3710 across seam 3730. Such strap and fastener and angled fastener attachment mechanisms may be repeated along the length of the seam (not shown). While this attachment mechanism is described in conjunction with commercial and industrial buildings, it may be used for any panelized construction system.

Figure 38 shows an example system for supporting and attaching a horizontal construction panel 3810 to a vertical construction panel 3820 with a bearing ledger 3830. Bearing ledger 3830 includes a block member 3831 and a side plate 3832. Vertical construction panel 3820, block member 3831, and side plate 3832 may be attached to one another using a variety of attachment mechanisms. For example, block member 3831 may be attached to vertical construction panel 3820 by a plurality of fasteners 3833 and 3834 and side plate 3832 may in turn be attached to block member 3831 by a plurality of fasteners 3835, 3836, and 3837. In an alternate preferred embodiment, vertical construction panel 3820, block member 3831, and side plate 3832 may be attached to one another by welds (not shown). Vertical construction panel 3820 and bearing ledger 3830 may define a space 3838 for accommodating a complimentary portion 3811 of horizontal construction panel 3810. When horizontal construction panel 3810 is positioned adjacent to vertical construction panel 3820, complimentary portion 3811 may be mated in space 3838 to support horizontal construction panel 3810. A

seam 3840 may be defined between horizontal construction panel 3810 and vertical construction panel 3820. A strap and fastener assembly 3841 may be used to attach horizontal construction panel 3810 to vertical construction panel 3820 across seam 3840. A plurality of strap and fastener assemblies (not shown) may be attached across the length of seam 3840 in order to hold horizontal construction panel 3810 in position relative to vertical construction panel 3820. Other attachment mechanisms are also possible. While this system for attaching a horizontal construction panel to a vertical construction panel is described in conjunction with commercial and industrial buildings, it may be used for any panelized construction system.

Figure 39 shows another example system for supporting and attaching a horizontal construction panel 3910 to a vertical construction panel 3920 with a bearing ledger 3930. Bearing ledger 3930 is steel member with U shaped cross-section. Alternate materials and configurations for bearing ledger 3930 are also possible. Bearing ledger 3930 may be pre-installed on vertical construction panel 3920 using a plurality of fasteners 3931 and 3932. Bearing ledger 3930 defines a shelf 3933. Horizontal construction panel 3910 may include a portion 3911 for engaging shelf 3933. Portion 3911 may mate with shelf 3933 and a surface 3921 of vertical construction panel 3920. Portion 3911 and shelf 3933 may define a seam 3940 where they are adjacent one another. A weld 3941 may attach horizontal construction panel 3910 to vertical construction panel 3920. Other attachment

mechanisms are also possible. While this system for attaching a horizontal construction panel to a vertical construction panel is described in conjunction with commercial and industrial buildings, it may be used for any panelized construction system.

Figure 40 shows an example system for supporting and attaching a horizontal construction panel 4010 to adjacent vertical construction panels 4020 and 4030 without a bearing ledger. First vertical construction panel 4020 and second vertical construction panel 4030 define a pocket 4040 for accommodating a portion 4011 of horizontal construction panel 4010. First vertical construction panel 4020 includes a top member 4021 defining the bottom 4041 of pocket 4040. Second vertical construction panel 4030 includes base complimentary member 4031 of a width substantially less than the width of top member 4021 and defining the side 4042 of pocket 4040. First vertical construction panel 2020 may be positioned to support horizontal construction panel 4010. Portion 4011 may be mated with top member 4021 of vertical construction panel 4020. A fastener 4043 may attach portion 4011 to top member 4021 to attach horizontal construction panel 4010 to first vertical construction panel 4020. Second vertical construction panel 4030 may then be positioned above first vertical construction panel 4020 and portion 4011 of horizontal construction panel 4010. Any of a variety of attachment mechanisms (not shown) may by used for attaching second vertical construction panel 4030 to first vertical construction panel 4020 and horizontal construction

panel 4010. A seam 4050 may be defined between second vertical construction panel 4030 and horizontal construction panel 4010. A seal 4051 may be placed over seam 4050. In one embodiment, horizontal construction panel 4010 is a roof panel and second vertical construction panel 4030 is a parapet wall panel. Seal 4051 may prevent leaking along seam 4050. While this system for attaching a horizontal construction panel to one or more vertical construction panels is described in conjunction with commercial and industrial buildings, it may be used for any panelized construction system.

Figure 41 shows an example system for supporting and attaching a vertical construction panel 4110 on a base structure 4120. A track 4130 is positioned on and attached to base structure 4120. Track 5130 may be made of any of a variety of materials, similar to construction panel frames and bearing ledgers. In a preferred embodiment, track 4130 is a steel member with a U cross-section. Track 4130 may be attached to base structure 4120 may any of a variety of attachment mechanisms. As shown, fastener 4131 passes through track 4130 and into base structure 4120. In an alternate embodiment, anchors are embedded in base structure 4120 for receiving and attaching track 4130 to base structure 4120. Vertical construction panel 4110 may include a base member 4111 and a track complimentary member 4112. Track complimentary member 4112 mates with the internal dimensions of track 4130 to support vertical construction panel 4110. Any of a variety of attachment mechanisms may be used to attach vertical construction panel 4110 to

track 4130. As shown, a plurality of fasteners 4132 and 4133 are inserted through track 4130 and into track complimentary member 4112 of vertical construction panel 4110. While this system for attaching a vertical construction panel to a base structure is described in conjunction with commercial and industrial buildings, it may be used for any panelized construction system.

Figures 42 and 43 show two example building configurations for a commercial, industrial, or other building using the construction panels, systems, and methods described above. Building configuration 4200 of Figure 42 and building configuration 4300 of Figure 43 include a plurality of rectangular bays. Each bay is defined by one or more vertical construction panels, as well as other construction panels (not shown). In one embodiment, each bay includes one or more horizontal or pitched construction panels defining a floor, a ceiling, and a roof corresponding in dimensions to the length and width of the bay. Building configurations 4200 and 4300 include a mixture of exterior vertical construction panels and interior vertical construction panels. Building configuration 4300 also includes a plurality of vertical supports. The construction panels of building configurations 4200 and 4300 may include any combination of features and building subsystems (not shown). The construction panels of building configurations 4200 and 4300 may include an materials, dimensions, and purposes appropriate to the function and type of building being constructed.

Building configuration 4200 includes four bays 4210, 4211, 4212, and 4213. Bay 4213 is divided into two sub-bays 4214 and 4215 by an interior wall 4233. Building configuration 4200 includes a plurality of exterior vertical construction panels 4220, 4221, 4222, 4223, 4224, 4225, 4226, 4227, 4228, 4229, and 4230. Building configuration 4200 includes a plurality of interior vertical construction panels 4231, 4232, and 4233. Bay 4210 is defined by exterior walls 4220, 4221, and 4230 and interior wall 4231. Bay 4211 is defined by exterior walls 4222, 4228, and 4229, and interior wall 4231. Bay 4212 is defined by exterior walls 4223, 4224, and a portion of 4227 and interior wall 4232. Bay 4213 is defined by exterior walls 4225, 4226, and a portion of 4227 and interior wall 4232. Bays may be designed as structurally autonomous units such that they may be arranged according to the desires of a particular builder and the conditions of a particular project. Building configuration 4200 may be an L-shaped strip mall intended to house a plurality of merchants. A first merchant may be assigned to bay 4210, a second merchant may be assigned to bays 4211 and 4212, a third merchant may be assigned to sub-bay 4214, and a fourth merchant may be assigned to sub-bay 4215.

Building configuration 4300 includes eight bays 4310, 4311, 4312, 4313, 4314, 4315, 4316, and 4317. Building configuration 4300 includes a plurality of exterior vertical construction panels 4320, 4321, 4322, 4323, 4324, 4325, 4326, 4327, 4328, 4329, 4330, and 4331. Building configuration 4300 includes a

plurality of interior vertical construction panels 4332, 4333, and 4334. Building configuration 4300 includes a plurality of vertical supports 4340 and 4341. Vertical supports 4340 and 4341 may include any variety of wood, metal, or concrete support beams, such as a pipe support. Bay 4310 is defined by exterior vertical construction panels 4320 and 4321 and vertical support 4340. Bay 4311 is defined by exterior vertical construction panel 4322 and vertical supports 4340 and 4341. Bay 4312 is defined by exterior vertical construction panel 4323, interior vertical construction panel 4332, and vertical support 4341. Bay 4313 is defined by exterior vertical construction panels 4324 and 4325 and interior vertical construction panels 4332 and 4334. Bay 4314 is defined by exterior vertical construction panels 4326 and 4327 and interior vertical construction panels 4334 and 4334. Bay 4315 is defined by exterior vertical construction panel 4328, interior vertical construction panel 4333, and vertical support 4341. Bay 4316 is defined by exterior vertical construction panel 4329 and vertical supports 4340 and 4341. Bay 4317 is defined by exterior vertical construction panels 4330 and 4331 and vertical support 4340. Building configuration 4300 may be an industrial building with a manufacturing floor in bays 4310 ,4311, 4312, 4315, 4316, and 4317, office space in bay 4313, and storage space in bay 4314.

Figure 44 shows a flow chart of a method of installing a commercial, industrial, or other building using panelized construction. The method may be followed using the construction panels, systems, and building configurations

described above. In step 4410, a base structure for a building module may be prepared. Preparation of a base structure may include identifying a building configuration to be used for the building module. Preparation of a base structure may include site-building a foundation for the building module according to the identified building configuration. Preparation of a base structure may include modifying an existing base structure to be compatible with the identified building configuration. Preparation of a base structure may include providing attachment mechanisms or structures for accommodating attachment mechanisms in the base structure. For example, preparation of a base structure may include attaching sills or tracks to a base structure using fasteners or another attachment mechanism. In step 4420, a wall panel or other vertical construction panel may be positioned upon the base structure. Position of the wall panel may depend upon the building configuration. In some embodiments, sills, rails, or other portions of attachment mechanisms may guide the positioning of the wall panel. For example, a wall panel with an complementary base member may mate with an appropriately located sill or rail. In step 4430, the positioned wall panel is attached to the base structure. Attaching the wall panel to the base structure may utilize any of a variety of attachment mechanisms, as described above. For example, the wall panel that has mated with a compatible sill or rail may accept one or more fasteners for attaching the wall panel to the sill or rail. In step 4440, the positioned wall panel may be attached to an adjacent structure. The adjacent structure may include a pre-existing

portion of a building structure or a previously placed construction panel. Where the positioned construction panel is the first vertical construction panel in a free standing building without pre-existing building structures, there may not be any adjacent structures, other than the base structure, to attach it to. Steps 4410 through 4440 may be repeated for a plurality of wall panels. Each additional construction panel may be attached to a previously positioned and attached construction panel. In step 4450, a roof panel is positioned over one or more wall panels. The roof panel may be a horizontal or pitched construction panel. Positioning the roof panel over one or more wall panels may include engaging the roof panel to one or more bearing ledgers. The bearing ledgers may be attached to the one or more roof panels or may be attached to a pre-existing structure. Alternatively or in combination, the roof panel may be placed on a top edge of one or more wall panels. Placement of the roof panel may include engaging another horizontal or vertical support, such as a ridge beam or pipe support. In step 4460, the positioned roof panel is attached to adjacent structures. The adjacent structures may include one or more wall panels, pre-existing building structures, support structures, and/or one or more adjacent roof panels. Attachment to adjacent structures may be accomplished using any of a variety of attachment mechanisms. Attachment to adjacent structures may also include providing seals between the newly placed roof panel and one or more adjacent structures. Steps 4450 and 4460 may be repeated for a plurality of roof panels. The method may also include the steps of placing one

or more floor or ceiling panels, interconnecting one or more building subsystems, adding additional exterior surface covering layers, such as roofing material or siding, and other additional steps as described above with regard to the various construction panels, systems, and attachment mechanisms.

This invention has been described in connection with the preferred embodiments. These embodiments are intended to be illustrative only. It will be readily appreciated by those skilled in the art that modifications may be made to these preferred embodiments without departing from the scope of the invention as defined by the appended claims.